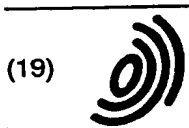


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(54) Diplexer for mobile phone

(57) The invention relates to a mobile phone (1) for at least two frequency bands (5, 10). An antenna (20) is coupled to a multiplex type filter (25). The multiplex type filter (25) contains at least two disparate bandpass filters (30, 35) for separate reception or transmission frequency bands (5, 10). A first bandpass filter (30) of the at least two disparate bandpass filters (30, 35) has as a passband a first frequency band (5). A second bandpass filter (35) of the at least two disparate bandpass filters (30, 35) has as a passband a second frequency band (10). An input impedance of the first bandpass filter (30) in the second frequency band (10) is higher than

an input impedance of the second bandpass filter (35) in the second frequency band (10), and an input impedance of the second bandpass filter (35) in the first frequency band (5) is higher than an input impedance of the first bandpass filter (30) in the first frequency band (5), so that coupling of signal power at frequencies in the first frequency band (5) to the second bandpass filter (35) and coupling of signal power at frequencies in the second frequency band (10) to the first bandpass filter (30) is essentially reduced.

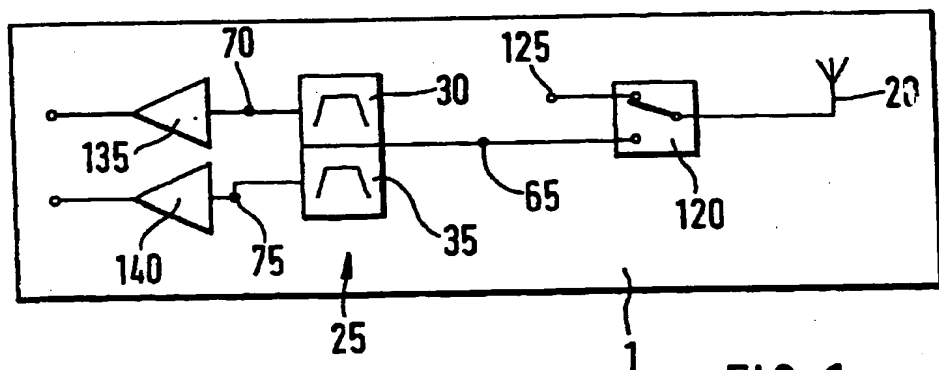


FIG. 1

EP 0 959 567 A1

Description

Prior Art

[0001] The invention proceeds from a mobile phone in accordance with the generic class of claim 1.

[0002] Mobile phones for at least two frequency bands are already known. The Motorola Micro Tac 8900 mobile phone provides automatic shifting between the GSM 900 MHz band (global system for mobile communications) and the GSM 1800 MHz band.

[0003] From the EP 0 355 973 B1, a digital mobile phone is known. The digital mobile phone includes an antenna, a receiver input for receiving signals on a first frequency, and a transmitter output for transmitting signals on a second frequency, different from the first frequency. The digital mobile phone comprises a duplex type filter, having a reverse attenuation from the transmitter output to the receiver input. The duplex type filter is used to couple the antenna to said receiver input and transmitter output. The duplex type filter replaces thereby an antenna switch to couple the antenna to the receiver and the transmitter respectively, and its control logic.

Advantages of the invention

[0004] In a mobile phone with the characterizing features of claim 1 a duplex type filter and more generally a multiplex type filter may advantageously be used either in a multiband receiver or a multiband transmitter chain to reduce circuit complexity by saving switches and the accompanying control logic in the multiband receiver or transmitter chain and therefore to save space on the printed circuit board and costs.

[0005] The features of the dependent patent claims enable further improvements of the invention.

[0006] Using known filter technologies as e.g. Surface Acoustic Wave (SAW) filters, it could be difficult to realize duplex type filters or multiplex type filters having widely separated passbands. Therefore, it may be a problem to secure high input impedance for the disparate bandpass filters in frequency bands outside of the corresponding passband. It is therefore an advantage, to use a matching circuit transforming a low input impedance of the corresponding bandpass filter to a high input impedance in the passbands of the other bandpass filters utilized in the multiplex type filter.

[0007] By using a transmission line for the matching circuit, circuit complexity may be further reduced and costs for unnecessary circuit components can be saved.

Drawings

[0008] Exemplary embodiments of the invention are shown in the figures and explained in greater detail in the description below. Figure 1 shows a block diagram

of a first embodiment of the invention in a reception line of a mobile phone, figure 2 a block diagram of a second embodiment of the invention in a reception line of a mobile phone, figure 3 a first circuit for a duplex type filter, figure 4 a second circuit for a duplex type filter, figure 5 a transmission line, figure 6 a first circuit for a triplex type filter, figure 7 a second circuit for a triplex type filter, figure 8 frequency diagrams for the impedance of the bandpass filters of a triplex type filter, figure 9 a block diagram of a third embodiment of the invention in a transmitter path of a mobile phone, and figure 10 a block diagram of a fourth embodiment of the invention in a transmitter path of a mobile phone.

Description

[0009] Figure 1 shows a block diagram of a first embodiment of the invention. In figure 1, 1 designates a mobile phone comprising a multiplex type filter 25 having a first bandpass filter 30 and a second bandpass filter 35. The multiplex type filter 25 in figure 1 therefore constitutes a duplex type filter. A common input 65 of the multiplex type filter 25 is connectable to an antenna 20 by a switch 120. A first transmitter port 125 is also connectable to the antenna 20 via the switch 120. Transmitter stages are connected to the first transmitter port 125 and are not shown in figure 1. The multiplex type filter 25 has a first output 70 and a second output 75 whereby the first output 70 is the output of the first bandpass filter 30 and the second output 75 is the output of the second bandpass filter 35. The common input 65 of the multiplex type filter 25 is shared by both bandpass filters 30, 35. Via the first output 70, the first bandpass filter 30 is connected to a first amplifier stage 135 and to further reception stages not shown in figure 1. Via the second output 75, the second bandpass filter 35 is connected to a second amplifier stage 140 and further reception stages not shown in figure 1.

[0010] The first bandpass filter 30 permits reception in a first frequency band 5 which is shown in figure 8a). The first frequency band 5 is the GSM 900 MHz frequency band. More precisely, the mobile phone 1 would receive signals in the first frequency band 5 at frequencies of approximately 947 MHz and transmit signals at frequencies of approximately 890 MHz via the antenna 20. The second bandpass filter 35 permits reception of signals via the antenna 20 in a second frequency band 10 at approximately 1800 MHz as shown in figure 8b), so in the GSM 1800 MHz band. The reception and transmission frequencies in the second frequency band 10 are separated in a similar manner as explained for the first frequency band 5. The first and the second frequency bands 5, 10 do not overlap and are widely separated in frequency. The first frequency band 5 is the passband of the first bandpass filter 30, and the second frequency band 10 is the passband of the second bandpass filter 35.

[0011] The switch 120 is controlled by a control logic

not shown in figure 1 to connect the antenna 20 to the receiving or the transmitting paths according to the requirements during a telephone call.

[0012] According to figure 8a) the first bandpass filter 30 presents an input impedance z of $50\ \Omega$ to the antenna 20 in the first frequency band 5. This impedance is adapted to the impedance of the antenna 20. The dotted line in figures 8a), b), and c) shows the filter input impedance Z as a function of the frequency f . So the first bandpass filter 30 has a high input impedance Z of some hundred Ohms in the second frequency band 10. The second bandpass filter 35 presents an input impedance Z of $50\ \Omega$ to the antenna 20 in the second frequency band 10 and a high input impedance Z of some hundred Ohms in the first frequency band 5.

[0013] In figure 2, a block diagram of a second embodiment of the invention is shown. In this embodiment, the antenna 20 of the mobile phone 1 is connectable via an antenna switch circuit 100 to the first transmitter port 125, a second transmitter port 130, a first receiver port 105, and a second receiver port 110. The transmitter ports 125, 130 are input ports of the antenna switch circuit 100 and the receiver ports 105, 110 are output ports of the antenna switch circuit 100. The antenna switch circuit 100 is controlled by a control logic not shown in figure 2 and connects the several ports 125, 130, 105, 110 to the antenna 20 according to the requirements during a telephone call. A transmitter line connected to the first transmitter port 125 and the second transmitter port 130 is not shown in figure 2. The first reception port 105 of the antenna switch circuit 100 is connected to a first input 85 of the multiplex type filter 25. The second reception port 110 of the antenna switch circuit 100 is connected to a second input 90 of the multiplex type filter 25. Thereby, the first input 85 of the multiplex type filter 25 is the input of the first bandpass filter 30 and the second input 90 of the multiplex type filter 25 is the input of the second bandpass filter 35. The first bandpass filter 30 and the second bandpass filter 35 share a common output 115 of the multiplex type filter 25, which is connected to the first amplifier stage 135 and further reception stages not shown in figure 2.

[0014] The effect of the multiplex type filters 25 in figure 1 and figure 2 is the same, only the input and output connection arrangements are different.

[0015] Figure 3 shows the multiplex type filter 25 of figure 1 in more detail. In figure 3, the common input 65 of the multiplex type filter 25 is connected to the first bandpass filter 30 via a first matching circuit 45 and to the second bandpass filter 35 via a second matching circuit 50. Thereby the first matching circuit 45 comprises a first inductor 165. At its first end the first inductor 165 is connected to the common input 65 and via a first capacitor 145 to ground. At its second end, the first inductor 165 is connected to the first bandpass filter 30 and via a second capacitor 150 also to ground. The second matching circuit 50 comprises a second inductor 170. At its first end, the second inductor 170 is connected to the

common input 65 and via a third capacitor 155 to ground. At its second end, the second inductor 170 is connected to the second bandpass filter 35 and via a second capacitor 160 also to ground.

[0016] Without using the first matching circuit 45, the input impedance Z of the first bandpass filter 30 depends on the frequency f according to the continuous line in figure 8a). This means, that for frequencies outside the first frequency band 5 the input impedance Z of the first bandpass filter 30 is approximately zero. Therefore, signals with frequencies of the second frequency band 10 would easily be coupled to the first bandpass filter 30 and therefore generate loss in the signal strength of the signal passed through the second bandpass filter 35, adapted to the antenna impedance of $50\ \Omega$ in the second frequency band 10. The first matching circuit 45 transforms the low input impedance Z of the first bandpass filter 30 outside the first frequency band 5, at least in the second frequency band 10, to a high input impedance Z of some 100 Ohms. This transformation is indicated in figure 8a) by arrows. Therefore, coupling of signals at frequencies outside the first frequency band 5, especially in the second frequency band 10, into the first bandpass filter 30 is strongly reduced. In the first frequency band 5, the first matching circuit 45 leaves the impedance Z of the first bandpass filter 30 at the antenna impedance of $50\ \Omega$.

[0017] In figure 8b), the input impedance Z of the second bandpass filter 35 is shown as a function of the frequency f . The continuous line in figure 8b) shows the input impedance Z of the second bandpass filter 35 as a function of the frequency f without using the second matching circuit 50. Thereby, the input impedance Z of the second bandpass filter 35 equals $50\ \Omega$ in the second frequency band 10 and equals approximately zero outside the second frequency band 10. The second matching circuit 50 transforms the input impedance Z of the second bandpass filter 35 at frequencies outside the second frequency band 10, especially in the first frequency band 5, to high values as indicated by arrows in figure 8b) and leaves the input impedance Z of the second bandpass filter 35 at approximately $50\ \Omega$ in the second frequency band 10. Therefore, coupling of signals at frequencies of the first frequency band 5 into the second bandpass filter 35 is strongly reduced. The input impedance Z of the second bandpass filter 35 after the transformation is shown as a dotted line in figure 8b).

[0018] An alternative matching circuit may be constituted by a transmission line 60 as shown in figure 5 for the first matching circuit 45 as an example. A transmission line can also be used for the other matching circuits in the multiplex type filter 25. The length of the transmission line 60 is thereby chosen e.g. as a quarter of the wavelength of the center frequency of the frequency band of the corresponding bandpass filter. For the example of figure 5, the center frequency of the first frequency band 5 which is the passband of the first bandpass filter 30 is at approximately 900 MHz. Such a

transmission line also leaves the input impedance Z in the passband of the corresponding bandpass filter at the antenna impedance of $50\ \Omega$ and increases the input impedance Z outside the passband of the corresponding bandpass filter to some hundred Ohms, especially in the passbands of the other bandpass filters utilized in the multiplex type filter 25.

[0019] The transmission line 60 may be a coaxial cable. The central conductor of the coaxial cable is connected at one end with the common input 65 and at the other end with the corresponding bandpass filter. The outer conductor of the transmission line 60 is connected to ground.

[0020] Figure 6 shows an example of a multiplex type filter 25 with three disparate bandpass filters 30, 35, 40 following a matching circuit 45, 50, 55, respectively. In comparison with the above described embodiments, the third bandpass filter 40 is added for a third frequency band 15, the center frequency of which is approximately at 1900 MHz. The third frequency band 15 may be the GSM 1900 MHz band and is the passband of the third bandpass filter 40, separated in frequency from the passbands of the first and second bandpass filters 30, 35, so that the passbands of the first, the second, and the third bandpass filter 30, 35, 40 do not overlap. According to figure 1, the embodiment shown in figure 6 is an example for a multiplex type filter 25 with a common input 65 and separate outputs. Thereby, in comparison with the embodiment of figure 1, the common input 65 additionally is connected to the third bandpass filter 40 via a third matching circuit 55. The output of the third bandpass filter 40 would be a third output 80 of the multiplex type filter 25. The third matching circuit 55 may have a structure as shown in figure 3 or figure 5. By choosing a transmission line for the third matching circuit 55 the length of the transmission line should be a quarter of the wavelength of the center frequency of 1900 MHz of the third frequency band 15.

[0021] Figure 8c) shows the input impedance Z of the third bandpass filter 40 as a function of the frequency f . The continuous line shows the input impedance Z of the third bandpass filter 40 as a function of the frequency f without the use of the third matching circuit 55. Thereby, in the third frequency band 15, the input impedance Z of the third bandpass filter 40 equals the antenna impedance of $50\ \Omega$. Outside the third frequency band 15, the input impedance Z of the third bandpass filter 40 equals approximately zero. The third matching circuit 55 transforms the input impedance Z of the third bandpass filter 40 outside the third frequency band 15 to a high impedance, especially in the first and second frequency band 5, 10, as indicated by arrows in figure 8c), and leaves the input impedance Z of the third bandpass filter 40 in the third frequency band 15 at approximately $50\ \Omega$. Therefore, coupling of signals at frequencies of the first and second frequency bands 5, 10 into the third bandpass filter 40 is strongly reduced. The first and the second matching circuits 45, 50 should transform the input

impedance Z of the corresponding first and second bandpass filter 30, 35 to a high value also in the third frequency band 15 to reduce coupling of signals at frequencies of the third frequency band 15 into the first and second bandpass filters 30, 35.

[0022] Figure 4 shows the multiplex type filter 25 of the second embodiment described according to figure 2 in more detail. The embodiment shown in figure 4 corresponds to the embodiment shown in figure 3 with two exceptions: First, in figure 4 the first matching circuit 45 and the second matching circuit 50 share the common output 115.

[0023] Second, in figure 4 the first bandpass filter 30 and the second bandpass filter 35 have different inputs whereas the input of the first bandpass filter 30 corresponds to the first input 85 of the multiplex type filter 25 and the input of the second bandpass filter 35 corresponds to the second input 90 of the multiplex type filter 25. The first input 85 and the second input 90 are not connected to each other. The function of the multiplex type filter 25 according to figure 4 is the same as the function of the multiplex type filter 25 shown in figure 3. The first and/or the second matching circuit 45, 50 may also be constituted by a transmission line, respectively, the length of which corresponding to a quarter of the wavelength of the center frequency of the passband of the preceding bandpass filter. Therefore, the outputs of the first and the second bandpass filter 30, 35 are matched to the common output 115 by the first and the second matching circuit 45, 50.

[0024] According to the second embodiment shown in figure 2, figure 7 shows an embodiment with a multiplex type filter 25 comprising three bandpass filters 30, 35, 40 with a following matching circuit 45, 50, 55 which may be a transmission line as described above, respectively. Therefore, the embodiment shown in figure 7 corresponds to the embodiment shown in figure 6 with two exceptions: First, in figure 7, the first, the second, and the third matching circuit 45, 50, 55 share the common output 115. Second, in figure 7 the first, the second, and the third bandpass filter 30, 35, 40 have different inputs which are separated from each other and therefore not connected electrically. The input of the first bandpass filter 30 corresponds to the first input 85 of the multiplex type filter 25, the input of the second bandpass filter 35 corresponds to the second input 90 of the multiplex type filter 25 and the input of the third bandpass filter 40 corresponds to a third input 95 of the multiplex type filter 25. Therefore, the outputs of the first, the second and the third bandpass filter 30, 35, 40 are matched to the common output 115 by the first, the second and the third matching circuit 45, 50, 55.

[0025] The function of the multiplex type filter 25 shown in figure 7 corresponds to the function of the multiplex type filter 25 shown in figure 6.

[0026] A multiplex type filter 25 with three bandpass filters 30, 35, 40 may be called a triplex type filter.

[0027] The embodiments, shown in figure 3 and figure

4 comprise two bandpass filters, where the first bandpass filter 30 has its passband in the first frequency band 5 and the second bandpass filter 35 has its passband in the second frequency band 10. The multiplex type filter 25 with two bandpass filters could also comprise the first bandpass filter 30 for the first frequency band 5 and the third bandpass filter 40 for the third frequency band 15. Such a multiplex type filter 25 with two bandpass filters could also comprise the second bandpass filter 35 for the second frequency band 10 and the third bandpass filter 40 for the third frequency band 15.

[0028] An example of dimensioning corresponding matching filters is given below. Therefore, it is supposed, that the multiplex type filter 25 comprises the second bandpass filter 35 and the third bandpass filter 40. The second bandpass filter 35 in this example would be preceded by the first matching circuit 45 and the third bandpass filter 40 in this example would be preceded by the second matching circuit 50. For the first inductor 165, a value of 3,3 nH is chosen. For the second inductor 170, a value of 2,7 nH is chosen. For the first, the second, the third, and the fourth conductor 145, 150, 155, 160, a value of 3,3 pF is chosen respectively. As a result, the input impedance Z of the second bandpass filter 35, according to figure 8b), would be higher than or equal to 400 Ω at least in the first frequency band 5 and in the third frequency band 15. According to figure 8c), the input impedance Z of the third bandpass filter 40 would be higher than or equal to 400 Ω at least in the first frequency band 5 and in the second frequency band 10. The input impedance Z of the second bandpass filter 35 and the third bandpass filter 40 in the corresponding passbands would be approximately equal to the antenna impedance of 50 Ω .

[0029] To prevent essential signal coupling at frequencies of the passband of one bandpass filter of the multiplex type filter 25 to another bandpass filter of the multiplex type filter 25, the input impedance Z of the other bandpass filter of the multiplex type filter 25 in the passband of the one bandpass filter of the multiplex type filter 25 should be high enough in comparison with the input impedance Z of the one bandpass filter of the multiplex type filter 25 in this passband.

[0030] According to figures 9 and 10, the multiplex type filter 25 can also be used in the transmitter path of the mobile phone 1. Thereby, figure 9 shows the multiplex type filter 25 comprising the first bandpass filter 30 and the second bandpass filter 35 sharing the common input 65. The first bandpass filter 30 is connected to the antenna switch circuit 100 via the first amplifier 135 and the second bandpass filter 35 is connected to the antenna switch circuit 100 via the second amplifier 140. Via the antenna switch circuit 100, the first amplifier 135 or the second amplifier 140 may be connected to the antenna 20. Via the antenna switch circuit 100, the antenna 20 may also be connected to receiver ports not shown in figure 9.

[0031] Figure 10 shows the multiplex type filter 25 with

the first bandpass filter 30 and the second bandpass filter 35 having separate, electrically not connected inputs and sharing the common output 115. The common output 115 is connected to the antenna 20 via the first amplifier 135.

[0032] Concerning the input impedance Z of the corresponding bandpass filters utilized in the multiplex type filter 25 and transformed by a matching circuit, respectively, if necessary, it is also important, to prevent essential signal coupling at frequencies of the passband of one bandpass filter of the multiplex type filter 25 to another bandpass filter of the multiplex type filter 25. Therefore, the input impedance Z of the other bandpass filter of the multiplex type filter 25 in the passband of the one bandpass filter of the multiplex type filter 25 should be high enough in comparison with the input impedance Z of the one bandpass filter of the multiplex type filter 25 in this passband, as described above, even if the input impedance Z of the bandpass filters of the multiplex type filter 25 in their passbands do not have to be adapted to the antenna impedance but to the output impedance of elements preceding the multiplex type filter 25. Matching circuits in the multiplex type filter 25 may also be constituted by transmission lines as described above.

[0033] If in the transmitter or receiver path the multiplex type filter 25 is used with bandpass filters sharing a common output, the following amplifier has to be a wideband amplifier, including in its passband the passbands of the bandpass filters of the multiplex type filter 25 used.

[0034] Regardless of the use of the multiplex type filter 25 in a transmitter or receiver chain, the desired frequency bands are separated by the bandpass filters included in the multiplex type filter 25. Therefore, switches can be saved to switch the desired frequency band into the transmitter or receiver path of the mobile phone. Such switches produce insertion loss and need a control logic. As narrow bandpass filters for the different frequency bands are needed in any case, they may, according to the invention, be combined to a multiplex type filter and therefore save the switches and there control logic.

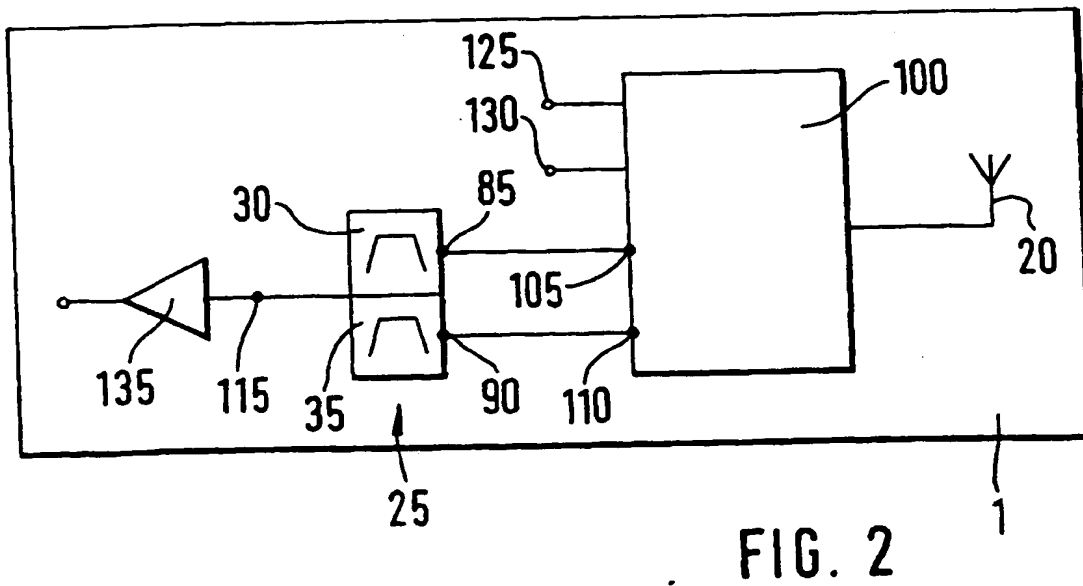
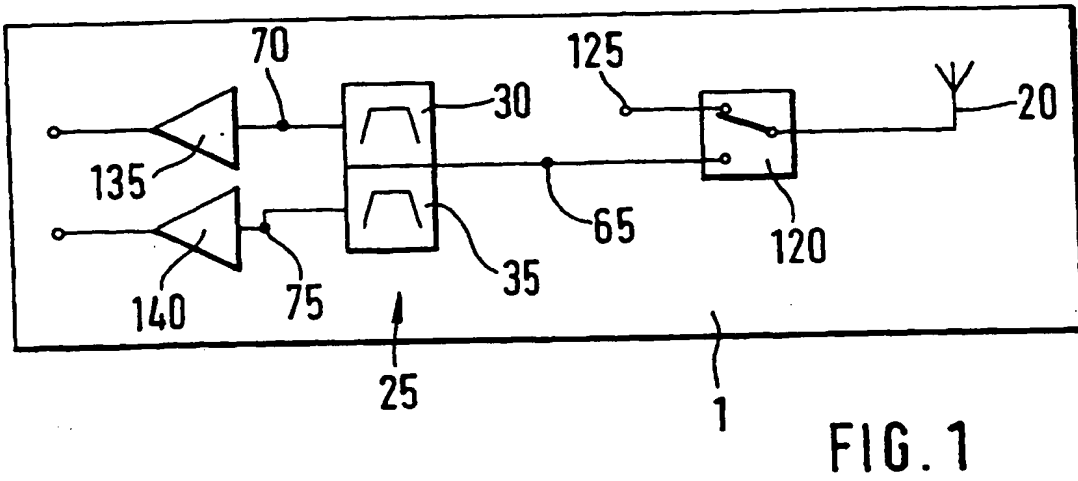
[0035] The multiplex type filter 25 may be a SAW filter (Surface Acoustic Wave), a stripline filter, a microstrip filter, a multilayer filter, a ceramic filter or may be based on helical resonators.

[0036] In all drawings of the described embodiments of the invention, same elements are designated with the same numerals, respectively.

It is also in the scope of the invention to use more than three bandpass filters optionally with a matching circuit, respectively, in the multiplex type filter 25, if more than three frequency bands are required for reception or transmission

Claims

1. Mobile phone (1) for at least two frequency bands (5, 10), characterized by an antenna (20) coupled to a multiplex type filter (25), the multiplex type filter (25) containing at least two disparate bandpass filters (30, 35) for either separate reception or separate transmission frequency bands (5, 10), a first bandpass filter (30) of the at least two disparate bandpass filters (30, 35) having as a passband a first frequency band (5), a second bandpass filter (35) of the at least two disparate bandpass filters (30, 35) having as a passband a second frequency band (10), an input impedance of the first bandpass filter (30) in the second frequency band (10) is higher than an input impedance of the second bandpass filter (35) in the second frequency band (10), an input impedance of the second bandpass filter (35) in the first frequency band (5) is higher than an input impedance of the first bandpass filter (30) in the first frequency band (5), so that coupling of signal power at frequencies in the first frequency band (5) to the second bandpass filter (35) and coupling of signal power at frequencies in the second frequency band (10) to the first bandpass filter (30) is essentially reduced.
2. Mobile phone (1) according to claim 1, characterized in that the multiplex type filter (25) contains a third bandpass filter (40) for a third frequency band (15), separated from the first and the second frequency band (5, 10), the third bandpass filter (40) having as a passband the third frequency band (15), an input impedance of the third bandpass filter (40) in the first and in the second frequency band (5, 10) is higher than an input impedance of the first bandpass filter (30) in the first frequency band (5) and higher than an input impedance of the second bandpass filter (35) in the second frequency band (10), an input impedance of the first bandpass filter (30) in the third frequency band (15) is higher than an input impedance of the third bandpass filter (40) in the third frequency band (15), an input impedance of the second bandpass filter (35) in the third frequency band (15) is higher than an input impedance of the third bandpass filter (40) in the third frequency band (15), so that coupling of signal power at frequencies in the first and second frequency band (5, 10) to the third bandpass filter (40) and coupling of signal power at frequencies in the third frequency band (15) to the first and second bandpass filters (30, 35) is essentially reduced.
3. Mobile phone (1) according to claim 1, characterized by the first frequency band (5) at approximately 900 MHz, especially the GSM 900 MHz band (global system for mobile communications), and the second frequency band (10) at approximately 1800 MHz, especially the GSM 1800 MHz band.
4. Mobile phone (1) according to claim 2, characterized by the third frequency band (15) at approximately 1900 MHz, especially the GSM 1900 MHz band.
5. Mobile phone (1) according to any one of the preceding claims, characterized in that in the multiplex type filter (25), at least one of the bandpass filters (30, 35, 40) follows a matching circuit (45, 50, 55), the matching circuit (45, 50, 55) transforming a low input impedance of the at least one of the bandpass filters (30, 35, 40) to a high input impedance in at least those of the frequency bands (5, 10, 15) different from the passband of the at least one of the bandpass filters (30, 35, 40).
6. Mobile phone (1) according to claim 5, characterized in that the matching circuit (45, 50, 55) is a transmission line (60).
7. Mobile phone (1) according to claim 6, where the length of the transmission line (60) corresponds approximately to a quarter of the wavelength of the center frequency of the passband of the corresponding bandpass filter (30, 35, 40).
8. Mobile phone (1) according to any one of the preceding claims, characterized in that the multiplex type filter (25) having one common input (65), the input (65) is shared by the at least two bandpass filters (30, 35), and the multiplex type filter (25) having an output (70, 75) for each of the at least two bandpass filters (30, 35) respectively.
9. Mobile phone (1) according to any one of claims 1 to 7, characterized in that the multiplex type filter (25) having one common output (115), the at least two bandpass filters (30, 35) of the multiplex type filter (25) sharing the common output (115), and the multiplex type filter (25) having an input (85, 90) for each of the at least two bandpass filters (30, 35), respectively.
10. Mobile phone (1) according to any one of the preceding claims, characterized in that the multiplex type filter (25) is a SAW (surface acoustic wave) filter.
11. Mobile phone (1) according to any one of claims 1 to 9, characterized in that the multiplex type filter (25) is a strip line filter, a microstrip filter, a multi-layer filter, a ceramic filter or based on helical resonators.



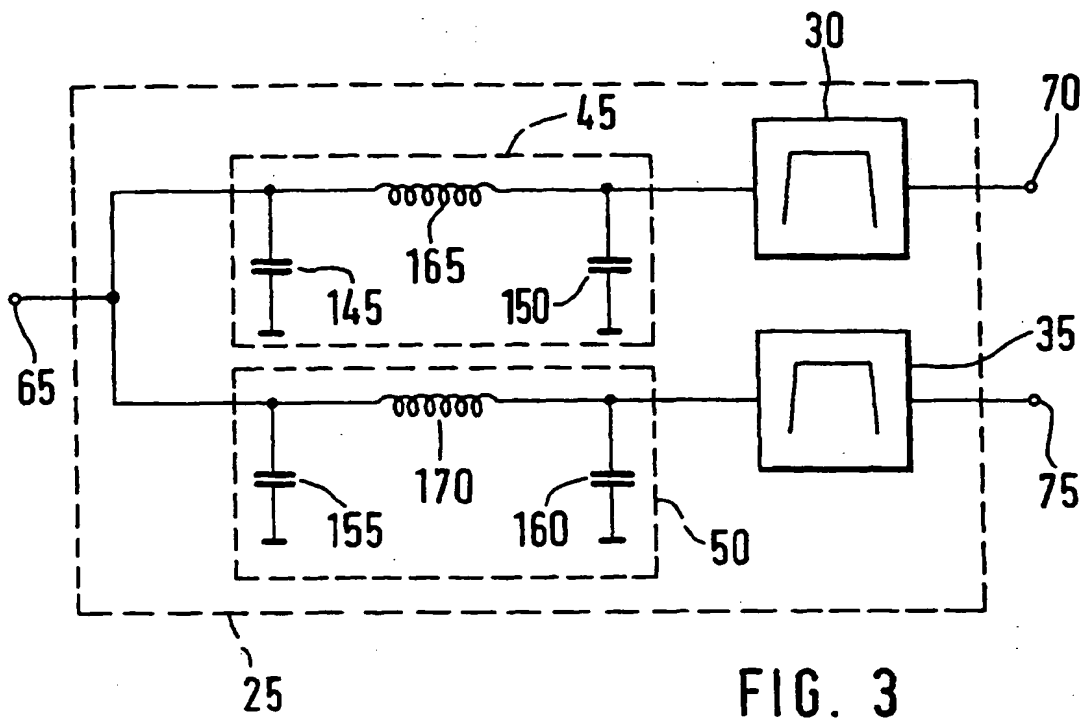


FIG. 3

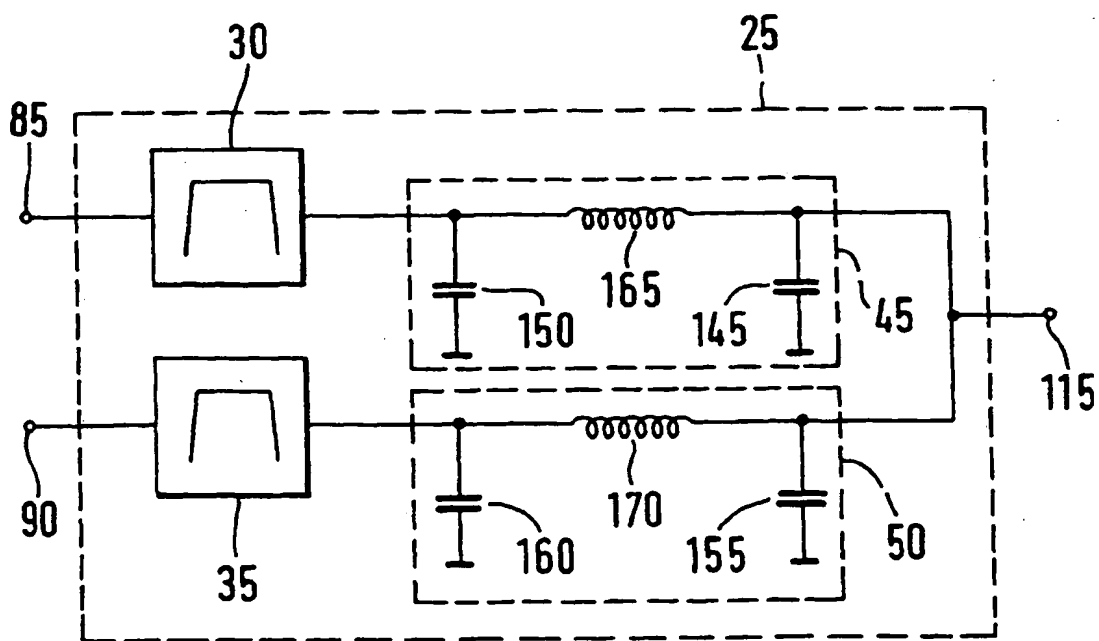


FIG. 4

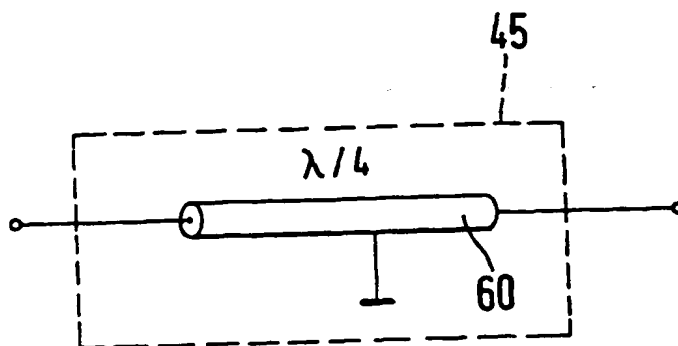


FIG. 5

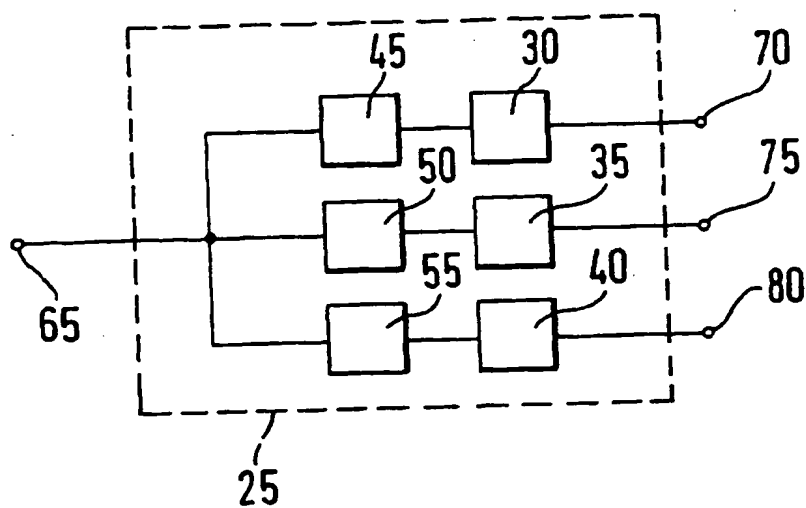


FIG. 6

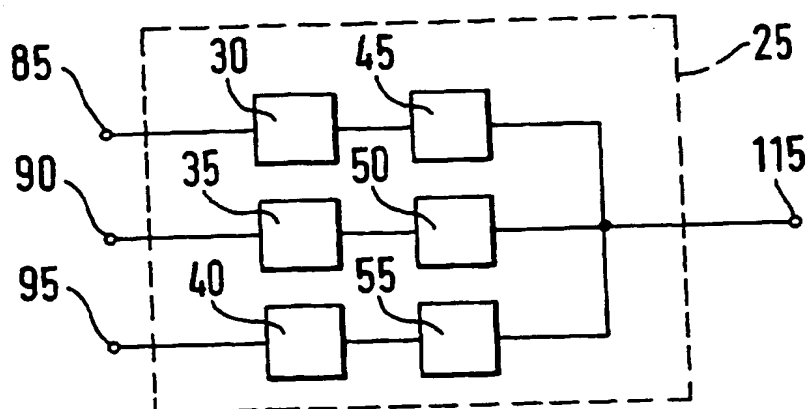


FIG. 7

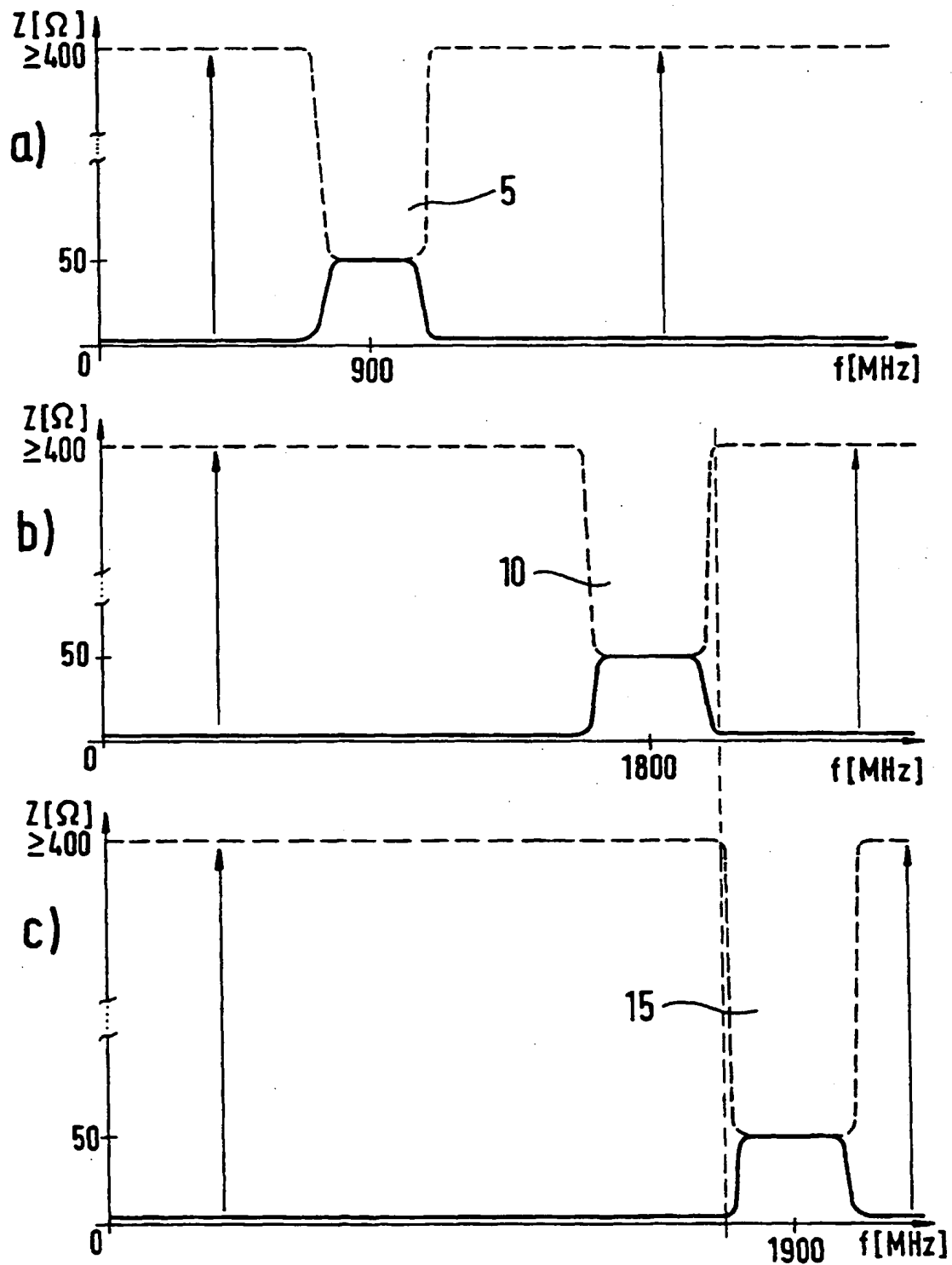


FIG. 8

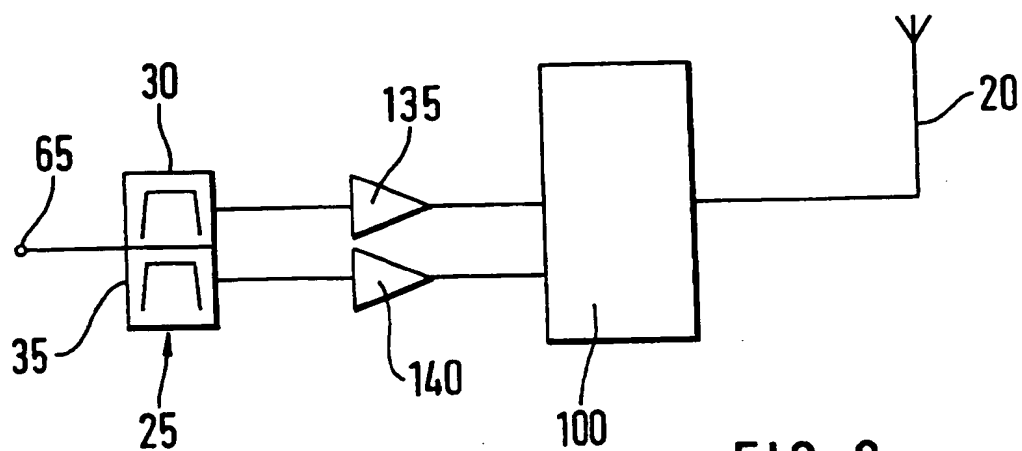


FIG. 9

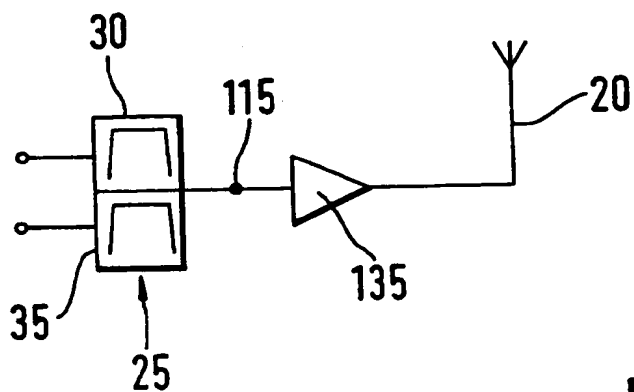


FIG. 10



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 10 9047

| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
|--|---|--|--|
| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.CI.8) |
| X | EP 0 465 315 A (MATRA COMMUNICATION) 8 January 1992 | 1,3,5-9, 11 | H04B1/52 H01P1/213 |
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| X | US 5 534 829 A (KOBAYASHI YASUMI ET AL) 9 July 1996 | 1,3,5-9, 11 | |
| A | * column 1, line 38 - column 3, line 55; figures 1,6 * | 2,4,10 | |
| X | EP 0 575 174 A (MITSUBISHI ELECTRIC CORP) 22 December 1993 | 1,3,5-10 | |
| A | * abstract; figure 3 * | 2,4,11 | |
| A | US 5 471 164 A (PENNY JAMES R) 28 November 1995 | 1-4 | |
| | * abstract; figure 4 * | | |
| | | | TECHNICAL FIELDS SEARCHED (Int.CI.6) |
| | | | H04B H01P |
| The present search report has been drawn up for all claims | | | |
| Place of search THE HAGUE | | Date of completion of the search 30 September 1998 | Examiner Andersen, J.G. |
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